Perspective

Sanitation Systems (/perspective/sanitation-systems-perspective)

Section

Sanitation Technologies (/sanitation-systems/sanitation-technologies)

Factsheet

Vertical Flow Constructed Wetland

العربية (/ar/sanitation-systems/sanitation-technologies/vertical-flow-constructed-wetland)

Applicable to

System 1 (/humanitarian-crises/rural-settings/sanitation/sanitation-systems/system-1%3A-single-pit-system)

System 6 (/humanitarian-crises/rural-settings/sanitation/sanitation-systems/system-6%3A-blackwater-treatment-system-with-infiltration)

System 7 (/humanitarian-crises/rural-settings/sanitation/sanitation-systems/system-7%3A-blackwater-treatment-system-with-effluent-transport)

System 8 (/humanitarian-crises/urban-settings

Application level

- City
- Household
- Neighborhood

Management level

- Household
- Public
- Shared

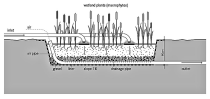
Inputs

- Blackwater
- Brownwater
- Greywater
- Effluent

Outputs

- Effluent
- Biomass

/sanitation
/sanitation-systems
/system-8%3A-
blackwater-transport-
to-%28semi-%29-
centralized-
treatment-system)
System 9
(/sanitation-systems
/sanitation-systems
/system-9%3A-
sewerage-system-
with-urine-diversion)



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Adapted from

Compendium of Sanitation Systems and Technologies. 2nd Revised Edition (/node/5587)

Executive Summary

A vertical flow constructed wetland is a planted filter bed that is drained at the bottom. Wastewater is poured or dosed onto the surface from above using a mechanical dosing system. The water flows vertically down through the filter matrix to the bottom of the basin where it is collected in a drainage pipe. The important difference between a vertical and horizontal wetland is not simply the direction of the flow path, but rather the aerobic conditions.

Advantages

- High reduction of BOD, suspended solids and pathogens
- Ability to nitrify due to good oxygen transfer
- Does not have the mosquito problems of the Free-Water Surface or Horizontal Wetland
- Less clogging than in a Horizontal Subsurface Flow

Disadvantages

- Requires expert design and construction, particularly, the dosing system
- Requires more frequent maintenance than a Horizontal Subsurface Flow Constructed Wetland
- A constant source of electrical energy may be required

Constructed Wetland

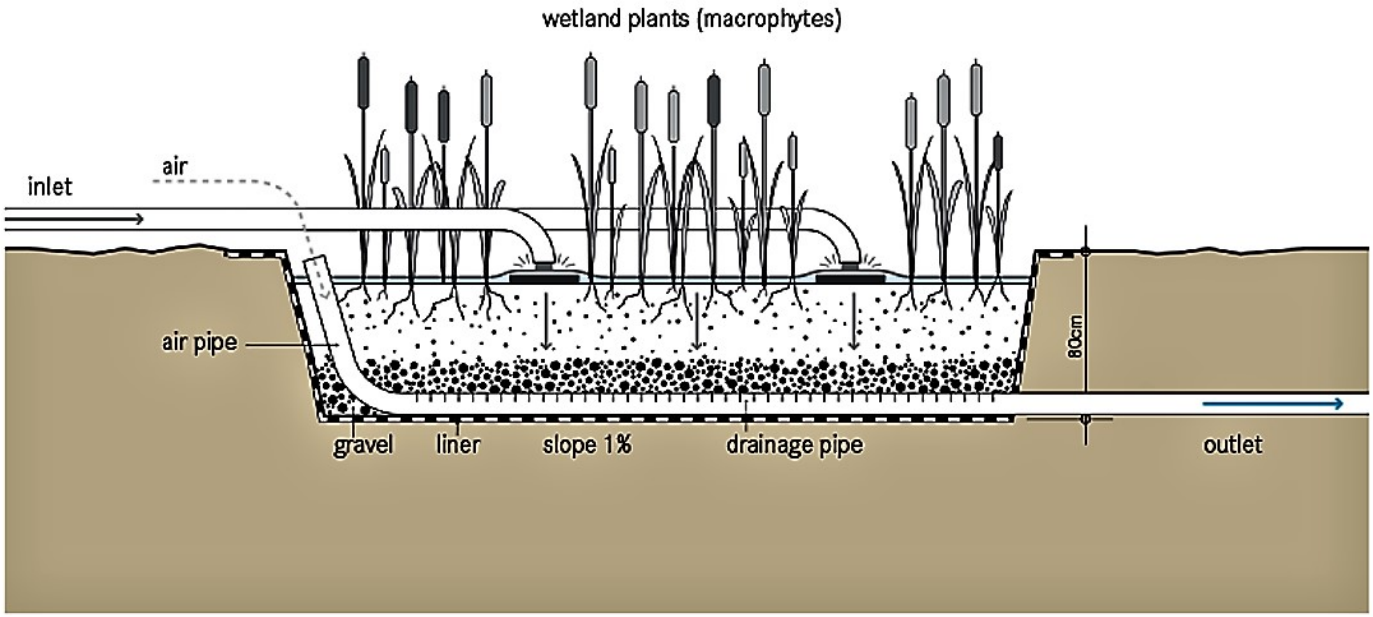
- Requires less space than a Free-Water Surface or Horizontal Flow Wetland
- Low operating costs
- Long start-up time to work at full capacity
- Not all parts and materials may be locally available

In	Out
Blackwater, Greywater, Brownwater	Fertigation Water, Treated Water

Introduction

By intermittently dosing the wetland (4 to 10 times a day), the filter goes through stages of being saturated and unsaturated, and, accordingly, different phases of aerobic and anaerobic conditions. During a flush phase, the wastewater percolates down through the unsaturated bed. As the bed drains, air is drawn into it and the oxygen has time to diffuse through the porous media.

The filter media acts as a filter for removing solids, a fixed surface upon which bacteria can attach and a base for the vegetation. The top layer is planted and the vegetation is allowed to develop deep, wide roots, which permeate the filter media. The vegetation transfers a small amount of oxygen to the root zone so that aerobic bacteria can colonize the area and degrade organics. However, the primary role of vegetation is to maintain permeability in the filter and provide habitat for microorganisms. Nutrients and organic material are absorbed and degraded by the dense microbial populations. By forcing the organisms into a starvation phase between dosing phases, excessive biomass growth can be decreased and porosity increased.



Schematic of the Vertical Flow Constructed Wetland. Source: TILLEY et al. (2014)

Design Considerations

The vertical flow constructed wetland can be designed as a shallow excavation or as an above ground construction. Clogging is a common problem. Therefore, the influent should be well settled in a primary treatment stage before flowing into the wetland. The design and size of the wetland is dependent on hydraulic and organic loads. Generally, a surface area of about 1 to 3 m2 per person equivalent is required. Each filter should have an impermeable liner and an effluent collection system. A ventilation pipe connected to the drainage system can contribute to aerobic conditions in the filter. Structurally, there is a layer of gravel for drainage (a minimum of 20 cm), followed by layers of sand and gravel.

Depending on the climate, Phragmites australis (reed), Typha sp. (cattails) or Echinochloa pyramidalis are common plant options. Testing may be required to determine the suitability of locally available plants with the specific wastewater. Due to good oxygen transfer, vertical flow wetlands have the ability to nitrify, but denitrification is limited. In order to create a nitrification-denitrification treatment train, this technology can be combined with a **Free-Water Surface (/factsheet/free-water-surface-cw)** or **Horizontal Flow Wetland (/taxonomy/term/2662/horizontal-subsurface-flow-cw)**.

Health Aspects/Acceptance

Pathogen removal is accomplished by natural decay, predation by higher organisms, and filtration. The risk of mosquito breeding is low since there is no standing water. The system is generally aesthetic and can be integrated into wild areas or parklands. Care should be taken to ensure that people do not come in contact with the influent because of the risk of infection.

Operation & Maintenance

During the first growing season, it is important to remove weeds that can compete with the planted wetland vegetation. Distribution pipes should be cleaned once a year to remove sludge and biofilm that might block the holes. With time, the gravel will become clogged by accumulated solids and bacterial film. Resting intervals may restore the hydraulic conductivity of the bed. If this does not help, the accumulated material has to be removed and clogged parts of the filter material replaced. Maintenance activities should focus on ensuring that primary treatment is effective at reducing the concentration of solids in the wastewater before it enters the wetland. Maintenance should also ensure that trees do not grow in the area as the roots can harm the liner.

Applicability

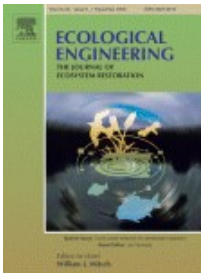
The vertical flow constructed wetland is a good treatment for communities that have primary treatment (e.g., **Septic Tanks (/factsheet/septic-tank)**) but are looking to achieve a higher quality effluent. Because of the mechanical dosing system, this technology is most appropriate where trained maintenance staff, constant power supply, and spare parts are available. Since vertical flow constructed wetlands are able to nitrify, they can be an appropriate technology in the treatment process for wastewater with high ammonium concentrations. Vertical flow constructed wetlands are best suited to warm climates, but can be designed to tolerate some freezing and periods of low biological activity.

Media PPT

Constructed Wetlands (PPT) (/media/3)

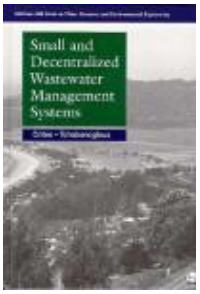
Library References

The Use of Vertical Flow Constructed Wetlands for on-Site Treatment of Domestic Wastewater: New Danish Guidelines



BRIX, H. ; ARIAS, C. A. (2005): The Use of Vertical Flow Constructed Wetlands for on-Site Treatment of Domestic Wastewater: New Danish Guidelines. In: Ecological Engineering: Volume 25 , 491-500.

Small and Decentralized Wastewater Management Systems



Decentralised wastewater management presents a comprehensive approach to the design of both conventional and innovative systems for the treatment and disposal of wastewater or the reuse of treaded effluent. Smaller treatment plants, which are the concern of most new engineers, are the primary focus of this book.

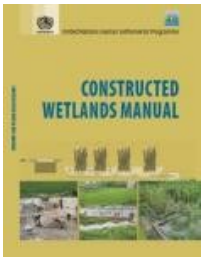
CRITES, R. TCHOBANOGLOUS, G. (1998): Small and Decentralized Wastewater Management Systems. New York: The McGraw-Hill Companies Inc

Treatment Wetlands. 2nd Edition

This book supports in making informed decisions regarding wetland design.

KADLEC, R. H. WALLACE, S. D. (2009): Treatment Wetlands. 2nd Edition. Boca Raton: CRC Press, Taylor & Francis Group **URL (https://www.researchgate.net/publication/284194314_Treatment_Wetlands_2nd_Ed_CRC_Press)** [Accessed: 09.06.2019]

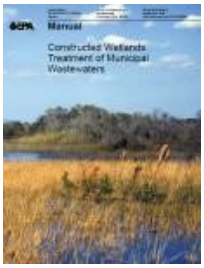
Constructed Wetlands Manual



This manual has been prepared as a general guide to the design, construction, operation and maintenance of constructed wetlands for the treatment of domestic wastewater as well as introduction to the design of constructed wetland for sludge drying.

UN-HABITAT (2008): Constructed Wetlands Manual. Kathmandu: UN-HABITAT, Water for Asian Cities Program **URL (http://www.un.org.np/sites/default/files /CWManual.pdf)** [Accessed: 15.02.2012]

Manual – Constructed Wetlands Treatment of Municipal Wastewater



This manual discusses the capabilities of constructed wetlands, a functional design approach, and the management requirements to achieve the designed purpose. The manual also attempts to put the proper perspective on the appropriate use, design and performance of constructed wetlands. Furthermore, the document contains two case studies.

U.S. EPA (1999): Manual – Constructed Wetlands Treatment of Municipal Wastewater. Washington D.C.: United States: Environmental Protection Agency (EPA) **URL (https://cfpub.epa.gov/si/si_public_record_report.cfm?dirEntryId=64144&Lab=NRMRL)** [Accessed: 09.06.2019]